CARABID FAUNA OF SOME TYPES OF FOREST IN THE NETHERLANDS (COLEOPTERA: CARABIDAE)

by

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ABSTRACT

Heijerman, Th. & H. Turin, 1989. Carabid fauna of some types of forest in the Netherlands (Coleoptera: Carabidae). – Tijdschrift voor Entomologie 132: 241–250, figs. 1–3, tables 1–3 [ISSN 0040–7496]. Published 1 December 1989.

Continuous pitfall trapping data were collected, consisting of year-samples of carabid beetles from 48 sites in different types of forest located in several geographic parts of the Netherlands. More than 18,000 carabids were caught. Numerical classification techniques were applied and these revealed that clusters of sites, classified on their carabid species composition, could be interpreted better in terms of their geographical position in the Netherlands, rather than in terms of forest type. Moreover, the carabid faunas of the coniferous forests investigated, appeared to be impoverished nor poor in species when compared with the faunas of deciduous forests.

Key words. – Carabidae; forest types; The Netherlands.

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INTRODUCTION

If one were to try to record as many species of forest carabids as possible from a single locality, one would probably prefer to sample a mixed deciduous forest, and certainly not a monotonous coniferous plantation, where all trees are approximately of the same age, size and are equidistant.

Den Boer (1963) studied the carabid faunas of several types of forest in the province of Drenthe (The Netherlands), and indeed concluded that the carabid faunas of coniferous forests are only poor sub-samples from those of dry deciduous forests. Coniferous forests in Drenthe not only contain lower densities of fewer carabid species, but also lack the characteristic species.

Between 1835 en 1945, the Dutch forest area increased from 170,000 to about 300,000 ha, which is about 8.5% of the total area of the Netherlands. This increase was due to the planting of various coniferous tree species. The area covered with deciduous forests thus decreased from 81% of the total forest area to about 30%. At present about 80% of the total forest area is covered with coniferous trees, and only 20% with deciduous tree species including scrubs. Deciduous forests often alternate with coniferous plantations in the same areas.

The patches of deciduous forests may therefore be regarded as more or less isolated ecological "islands", surrounded by inaccessible areas. This hypothesis would imply that not only agricultural fields and meadows may function as barriers to the exchange of carabid beetles between discontinuous (spatially separated) habitats, but also that conifer plantations may hamper dispersal to some extent. Of course, this isolating effect would drastically affect the distribution of stenotopic species, and of species with poor powers of dispersal.

The possible effects of fragmentation and isolation of the distribution of carabid species that differ in their powers of dispersal, were recently studied (Turin & Den Boer 1988).

In the present study the carabid faunas of several forest types are described, the sampling sites are classified, and the general applicability of the conclusion of Den Boer (1963), as mentioned above, is tested. The results of our study seem relevant in evaluating the possible role of conifer plantations as ecological barriers, and therefore in interpreting some of the results of the project of Turin & Den Boer (1988).

Turin and Heijerman (1988) classified the Dutch carabid species according to their association with forest habitats, and where we speak of "true forest carabids" we refer to the stenotopic and eurytopic forest species as distinghuished in that paper.

Methods

Sampling technique and location of sampling sites

We selected 14 sampling areas, distributed over five geographical regions in the Netherlands (fig. 1). Each sampling area consisted of a forest area containing patches of different types of woodland: oak-birch, larch, spruce, and/or douglas-fir. Sets of 5 pitfall traps were placed in each of these different forest types. In total 48 pitfall series were used, covering 48 different sampling localities. Within each pitfall series, traps were placed at a distance of 6 to 10 m from each other. The traps were provided with 4% formalin as a preservative. Table 1 gives a listing of the sampling localities for each sampling area.

The traps were emptied at irregular time intervals during continuous operation for a whole year, from spring 1983 to spring 1984. All those carabid specimens taken from the five pitfall traps of a set together during a year, constitute a "year- sample".

Statistical analysis

A data set was constructed containing the year-samples of each species for each of the sampling localities. Another data set was produced for only those species that were classified as true forest species by Turin and Heijerman (1988). In order to simplify, visualize and to investigate the internal structure of such data matrices and to obtain information about the presence of clusters, two types of multivariate analyses were performed on these data sets. Both ordination and cluster analysis were used. For information about the exact principles and presuppositions of these methods, we will refer to the literature.

Ordination and cluster analysis. – As an ordination technique we have used DECORANA to perform Detrended Correspondence Analysis (DCA) (e.g. Hill 1979a). This technique can be applied to investigate whether the sample sites can be arranged

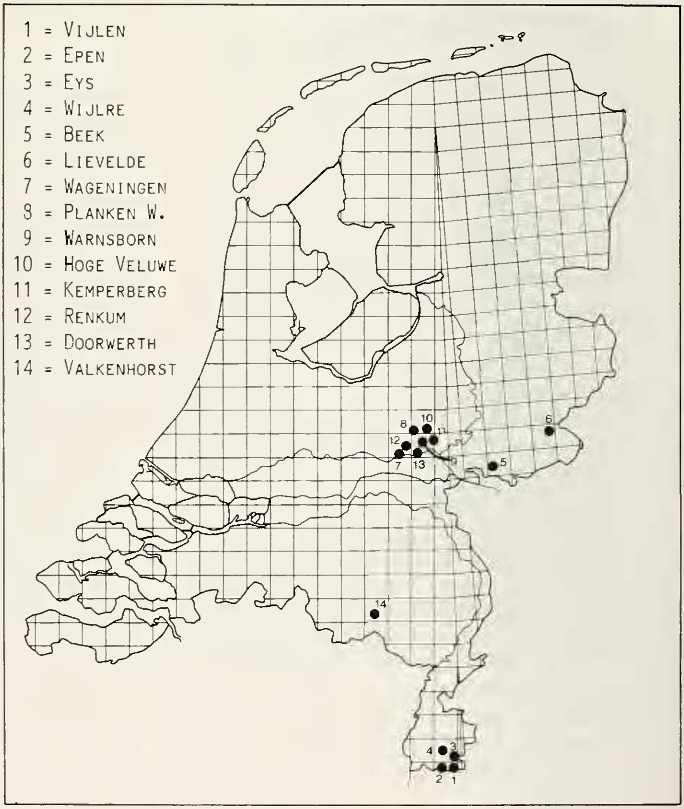

Fig. 1. Location of the forest sampling sites in The Netherlands.

Table 1. The 48 sampling sites, classified according to forest type and forest area. Given are the numbers of samples (pitfall series) for the different kinds of forests and the serial numbers.

Geographical group	forest area	1)	forest type oak-birch	larch	spruce	douglas	serial number
Southern part of Limburg	1. Vijlen	TH+KA	2	2	3	–	L1,2,5,7,8,11,13
	2. Epen	TH+KA	1	–	2	–	L3,4,10
	3. Eys	TH+KA	1	1	–	–	L6,9
	4. Wijlre	TH+KA	–	–	1	–	L12
Beek, Gelderland	5. Beek	TH	1	2	–	1	B1,2,3,4
Lievelde, Achterhoek	6. Lievelde	EP	2	1	2	–	A1,2,3,4,5
Southern Veluwe	7. Wageningen	TH	1	2	2	1	M18,19,20,21,22,23
	8. Planken Wambuis	KB	–	2	2	–	M1,2,3,4
	9. Warnsborn	KA	–	2	1	–	M5,6,9
	10. Hoge Veluwe	KA	–	1	1	–	M7,10
	11. Kemperberg	KA	1	–	1	–	M8,11
	12. Renkum	HT	–	2	–	2	M12,13,14,15
	13. Doorwerth	HT	2	–	–	–	M16,17
Brabant	14. Valkenhorst	FS	1	1	1	–	NB1,2,3
Total			12	16	16	4	48

1) Investigators: EP = E. Penterman; FS = F. Smulders; HT = H. Turin; KA = K. Alders; KB = K. Booij and TH = Th. Heijerman

along one or more hypothetical axes. These axes are constructed from the data matrix itself and may or may not coincide with gradients of real environmental variables. Subsequent consideration of the ecological requirements of the species may be of help to interpret the hypothetical gradient in terms of real environmental variables. Two Way Indicator Species Analysis was also carried out, using the TWINSPAN program (Hill 1979b). This method can be classified as a divisive, polythetic technique, and groups sample sites into hierarchical clusters, on a basis of the common presence of indicator species and/or preferentials.

Diversity aspects. – The individual sample sites were described in terms of (1) total number of species and (2) total number of individuals. These parameters were calculated for the total data matrix and for the matrix containing the forest species separately. They were used to investigate whether or not the carabid species composition of the various types of coniferous forests constituted a poor reflection of the communities of the deciduous sites. The significance of differences found were tested by the WILCOXON test.

RESULTS

The data matrices

The total carabid sample consisted of 18,522 specimens of 88 species (0.21 specimens trap* day^{-1}), twelve of them belonging to the stenotopic forest species, ten eurytopic forest species (sensu Turin & Heijerman 1988), and the others being non-forest species. The total number of specimens of true forest species was 17,281.

It is not practicable to present the complete data set; table 2 gives the abundances of only the 22 true forest species. The complete data set, however, is available on request.

Table 2. The total numbers of specimens (year-samples) of "true forest species" for each of the 48 pitfall series. The upper part of the table shows the stenotopic forest species and the lower part the eurytopic forest species (sensu Turin & Heijerman 1988).

Serial number	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	B1	B2	B3	B4	A1	A2	A3	A4	A5	M1	M2	M3	M4
Abax parallelepipedus	169	287	25	8	44	13	51	145	368	135	519		165	6	4	32	6						24	19	46	64
Abax parallelus	2	1								4																
Amara brunnea																										
Calathus rotundicollis								1	1	9	2	3					1	102	5	1	165	41	2	3		1
Carabus nemoralis			4									1	1	4	18	49	24	1		7	14	1	7		7	1
Cychrus caraboides		8			1		8	4			14						10		3	3				1		
Harpalus quadripunctatus																										
Leistus rufomarginatus			1			1	1	2	1	3		2			1	2	153	2	3	1	7	7		2		1
Notiophilus rufipes																	29									
Pterostichus cristatus				1						8																
Pterostichus oblongopunctatus	53	64	100	73	15	13	100	299	48	6	198		89	8	11	13	15	13	3	38	367	43	7	19	4	6
Trichotichnus nitens	1	2				5			46		72															
Agonum assimile											1							1			285					
Calathus micropterus																									10	
Carabus coriaceus	9	7	7	3	45		95	63		12	50		2	4	4	12	31									
Carabus problematicus	941	750	213	452	204	137	515	588	30	17	729		352	12	16	55	4						119	187	10	20
Carabus violaceus	26	10	3	3	21	30	4	20	80		31		16	6	1	41	20						10	6	9	4
Leistus spinibarbis																										
Nebria brevicollis				1						4		8					4	1		1	83	1				
Notiophilus biguttatus	2					2			1	1			2		4				3		19	10	1	8		5
Stomis pumicatus									1								8			2						
Trichocellus placidus																					1					
Forest type	sp	sp	sp	sp	la	la	la	ob	ob	ob	ob	sp	sp	la	la	do	ob	sp	sp	ob	ob	la	sp	sp	la	la

(Table 2 continued)

Serial number	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	NB1	NB2	NB3	Total
Abax parallelepipedus	82	81	15	42	24	123	103	38	94	85	6	4	4	5	7	2	8	9					2862
Abax parallelus	10			1	7		1																26
Amara brunnea																	6						6
Calathus rotundicollis		1			1	2	4	71	27	25	1			1	2			1	27		17	2	566
Carabus nemoralis	65	20	12		25	41	17	5	6	26	45	1	12	19	29	4	16	13	1			16	512
Cychrus caraboides		1								1		3	2	3		1	4		4				71
Harpalus quadripunctatus												1	6										7
Leistus rufomarginatus	2	4		8	12		4	6	2	2		10	10	2	15		3		34	13	15	4	336
Notiophilus rufipes		3			1		3		1	1	2	12	7	7	4	1	41	11	25		45	2	195
Pterostichus cristatus																							9
Pterostichus oblongopunctatus	90	85	3	37	81	9	21	96	22	8	9	18	295	15	5	1	17	36	106	99	237	125	3020
Trichotichnus nitens																							126
Agonum assimile							3	1															291
Calathus micropterus								6		10										1	39	9	75
Carabus coriaceus																							344
Carabus problematicus	346	160	97	186	518	293	81	155	136	85	38	26	147	23	87	9	27	24	7	25	31	128	7980
Carabus violaceus	18	14	1	4	23	6	1	10	3	6	7			8	14	5	21	7	1				490
Leistus spinibarbis																					1	3	4
Nebria brevicollis	5			3	26		2	7	6	1			4	2					5				164
Notiophilus biguttatus	1	1	3	1	2	5	3	5	2	7	6	1	5	12	3	3	18	19	7			1	163
Stomis pumicatus								1				1	7	2	1			2	8				33
Trichocellus placidus																							1
Forest type	la	la	la	sp	sp	sp	ob	do	do	la	la	ob	ob	sp	do	la	la	sp	ob	sp	ob	la	17281

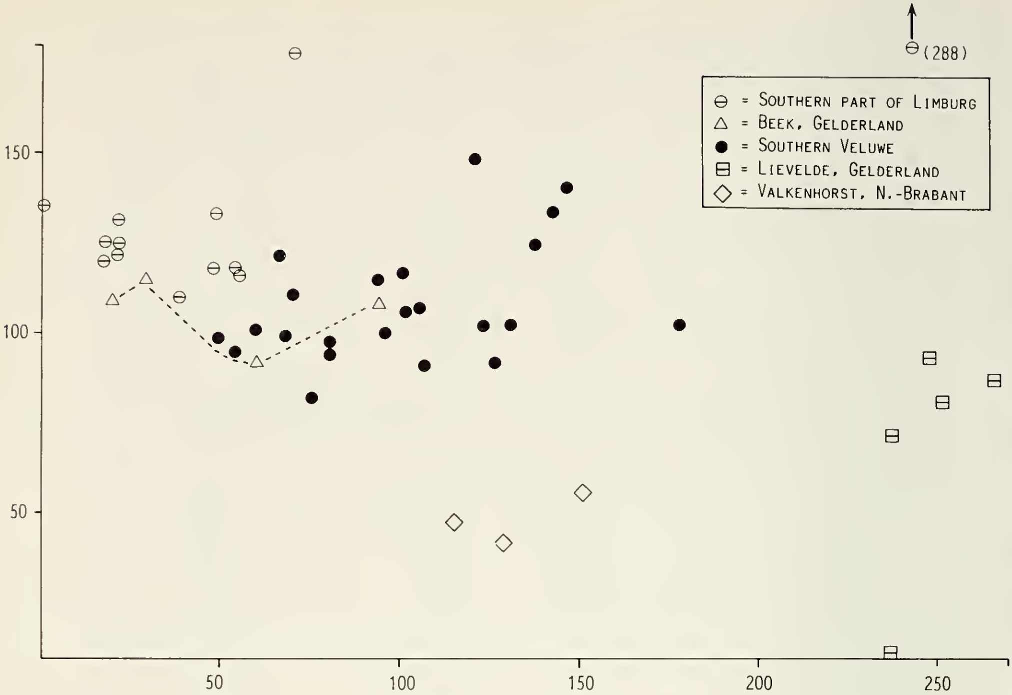

Fig. 2a. DCA-ordination (Detrended Correspondence Analysis). The sampling sites are marked according to their geographical position in the Netherlands.

Statistical analysis

Ordination and cluster analysis. – The results of the DCA-ordination are presented in fig. 2. The analysis was performed using all species and all sampling sites, and the original numbers of specimens were transformed to their logarithms. In fig. 2a the sampling sites have been marked according to their geographical position in the Netherlands. In fig. 2b again the same sampling sites are shown, but now the forest type is indicated. The positions of sampling sites along the axes, representing hypothetical gradients, obviously are not determined by the type of forest habitat, but rather by their geographical position. This seems particularly obvious where it concerns the localities from Midden-Nederland, Lievelde, Valkenswaard and the Southern part of Limburg (Zuid-Limburg), exclusive of Wijlre. The Beek sample sites do not form a coherent cluster, but are scattered among those from Zuid-Limburg and Midden-Nederland. Wijlre constitutes a very exceptional sampling site, being situated in a douglas-fir stand very close to the river Geul. Within Midden-Nederland clusters of forest sites are rather obsolete. Clusters within the main geographical regions are not indicated in the figures. Similar results were obtained using the forest species alone, and are therefore not presented here.

Fig. 3a and fig. 3b show the results obtained by TWINSPAN, based respectively on all carabid species and on the forest species alone. Sampling sites are marked according to their geographical position as well as to the forest type. The main geographical regions again appear to constitute more or less concrete clusters; the Zuid-Limburg localities, exclusive of Wijlre and inclusive of two Beek sites, are grouped together in fig. 3a. Also the five sites of Lievelde constitute a clear cluster. The Beek sites are again distributed among the Zuid-Limburg and the Midden-Nederland groups. The Valkenswaard sites and the Midden-Nederland sites themselves do not fall into clear clusters. Fig. 3b shows a rather similar, though somewhat less clear picture.

From both the ordination and the TWINSPAN analyses it can be concluded that the geographical position, and not the forest type, is the important factor determining the species composition of a sampling site. It therefore seems impossible to characterize the different types of forest in terms of the presence of particular carabid species.

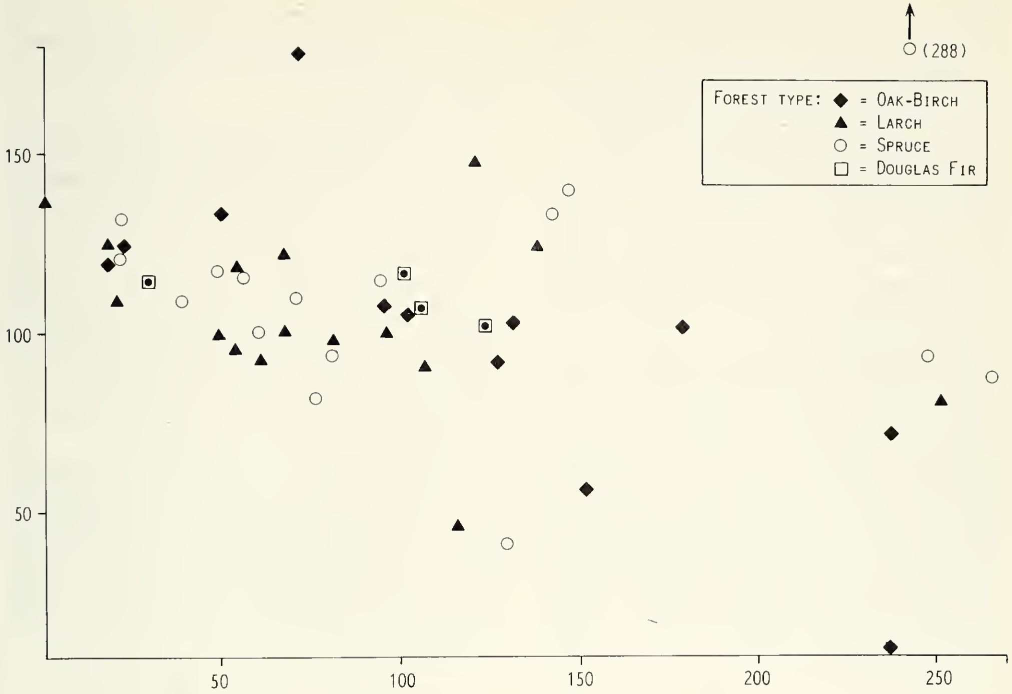

Fig. 2b. DCA-ordination, but the sites are now marked according to the forest type.

Diversity

The results of the diversity analysis are presented in tables 3a and 3b; in the first table all species were considered and in the latter table only the forest species were used in the calculations. In these tables sites were grouped according to forest type. The WILCOXON-test was used to test for differences in the mean values of the diversity statistics, between forest types. For all species together, it can be concluded that there are more specimens of carabids in deciduous forests as compared with larch forests. Regarding the forest species, more species of carabids were caught in deciduous forests as compared with both larch and spruce forests.

Geographical clusters

Species abundance data can be used to define the geographical clusters of sites that were detected. We will not present all the indicator species and preferentials as recognized by TWINSPAN for each cluster, but only try to characterize the clusters making use of the most important indicator species as well as the abundance data from table 2.

Zuid-Limburg. From table 2 it can be seen that *Carabus coriaceus* occurs on almost all Zuid-Limburg sites, and also in all Beek sites. Thiele (1977) summarized the data from a great number of investigations of carabids of the central European forest communities of several associations of the Fagetalia and the Quercetalia (see his table 5). *C. coriaceus* appears to be an important species of several forest types in mountains. All Zuid-Limburg sites except Wijlre, are situated at least 180 m above sea level, and the sites near Beek are situated on a lateral moraine (40 m above NAP [sea level]). However, this species is also known from dikeslopes and forests in the Betuwe (< 10 m above NAP). The most dominant species in Zuid-Limburg are *Abax parallelepipedus, Pterostichus oblongopunctatus, Carabus violaceus* and *C. problematicus*, which are also among the most abundant ones on many other sites. *C. problematicus* is characterized by Thiele (1977) as a species of mountains with no strict affinity to a particular type of forest. The three other species mentioned also occur in central Europe, independent of type of forest habitat. Rather striking is the absence of *C. nemoralis*, also a species not characteristic of a specific forest habitat, and common in all other geographical clusters. Also *N. rufipes*, a species with a peak occurrence in lowland Quercetalia, has not been caught. Geographical cluster 4 (fig. 3a) contains all Zuid-Limburg sites but one (Wijlre) and two Beek sites, and is defined by the indicator species *C. coriaceus* and the non-forest species *P. vernalis* and *P. madidus*. *T. nitens* and *P. cristatus* are restricted to Zuid-Limburg. The last three species mentioned are important species of the Fagetum forests in central Europe (Thiele 1977).

Midden-Nederland. Cluster 5 (fig. 3b) containing all but three Midden-Nederland sites, is defined by TWINSPAN by the indicator species *C. nemoralis*. This species is indeed less abundant in the other geographical clusters except for the Beek sites. Cluster 5 (fig. 3a) is characterized not only by *C. nemoralis* but also by *N. biguttatus* and the stenotopic forest species *N. rufipes*. True forest species restricted to one or more Midden-Nederland sites are *A. brunnea* and *H. quadripunctatus*. These two species are not menitoned by Thiele (1977) in his table 5. *N. biguttatus* appears to be an important forest species with no strict affinity to a particular forest type.

Beek. The Beek sites do not constitute a homogenous geographical cluster; the sites intermingle with Zuid-Limburg (through the occurrence of *C. coriaceus*) and with Midden-Nederland (through the occurrence of *C. nemoralis*). Also Beek has no unique true forest species.

Valkenswaard. The Valkenswaard sites are mainly characterized through the (almost) complete absence of a number of forest species that are abundant in the other areas: *C. nemoralis, A. parallelepipedus* and *C. violaceus*. There is one unique forest species: *L. spinibarbis*, a species not mentioned by Thiele.

Lievelde. Again *A. parellelepipedus* is totally absent, as are *C. violaceus* and *C. problematicus*. *Calathus rotundicollus* is the most dominant species and is much more abundant here than in the other areas. *C. rotundicollis* is not mentioned by Thiele as an important species of central European for-

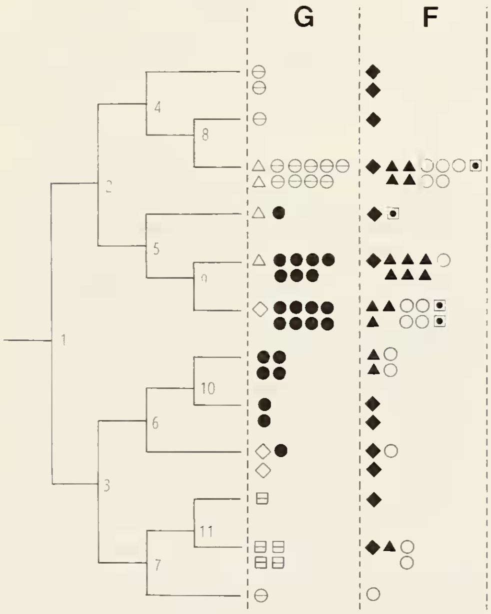

Fig. 3a. Dendrogram showing the results of the TWINSPAN cluster method, for all sampled species. G: sites are marked according to their geographical position. F: sites are marked according to the forest type. For meaning of the symbols see fig. 2.

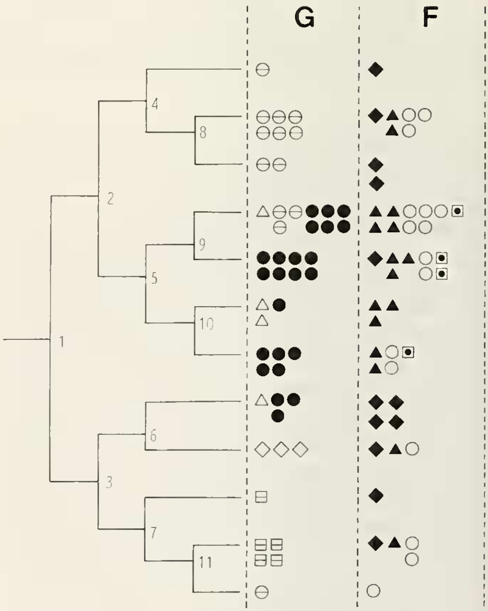

Fig. 3b. Dendrogram showing the results of the TWINSPAN cluster method for the forest species alone. Details as in fig. 2a.

Table 3. Diversity statistics per forest type. 3a: calculated for all species, 3b: only true forest species. X: mean number, SD: standard deviation. N-tot: total number of specimens per pitfall series, S-tot: number of species.

3a.		N-tot		S-tot		H-tot	
Forest type	N	X	SD	X	SD	X	SD
oak-birch	12	572	491	15.6	5.4	1.5	0.3
larch	16	240	208	12.3	5.0	1.6	0.5
spruce	16	421	305	13.4	7.2	1.3	0.6
douglas	4	271	106	12.5	4.7	1.6	0.1

3b.		N-tot		S-tot		H-tot	
Forest type	N	X	SD	X	SD	X	SD
oak-birch	12	537	495	9.5	1.8	1.4	0.2
larch	16	229	211	7.8	1.8	1.4	0.3
spruce	16	394	368	7.4	2.2	1.0	0.4
douglas	4	268	105	9.8	2.1	1.6	0.1

ests, but this species is recorded as the most dominant species in a mixed forest in Hall (DDR) (Heckendorf et al. 1986) and in a mixed forest in Foljuif (France) (Lecordier & Benest 1982). *T. placidus* is the only unique true forest species.

DISCUSSION AND CONCLUSIONS

Loreau (1984) studied the carabid communities of a pine wood and a beech forest in Lembek (Belgium). He found the beech forest to be inhabited by more forest species compared with the pine wood, to possess more characteristic species and to have a higher species diversity. Inspection of the values of the three components of diversity as calculated by Loreau, however, reveals that differences are very small (l.c. Tableau V). Amongst other things he finally concluded that the pine wood is characterized by an impoverished carabid community. Recently Heckendorf et al. (1986) studied the carabid communities of four types of forests near Halle (DDR). The beech forest and the pine forest communities were characterized as rather poor in species as well as individuals.

These two examples confirm the findings of Den Boer (1963) that coniferous forest types in general can be regarded as marginal habitats for true forest species, and that conifer plantations may indeed act as barriers to the dispersal of carabids between deciduous forest patches. These conclusions, however, are not really supported by our data. No differences were found in the composition of the carabid faunas of the forest types investigated, nor are there any overall differences in the number of species or the total number of specimens between deciduous forests on the one hand and conifer forests on the other. Our data strongly indicate that the geographical position of the forest within the Netherlands, constitutes a very important factor determining the faunal composition. Also the idea that coniferous forests may act as barriers that may hamper dispersal of forest carabids between deciduous forests needs reconsideration.

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